Telecommunications Trends for 2004 and Beyond

Vermont's telecommunications networks and services will be heavily influenced by national and global trends in telecommunications over the next seven years. Change is a constant in telecom, and the field of telecommunications continues a rapid pace of development. Telecommunications in many forms continues to become more Internet-like and wireless technology has continued to evolve and grow, sometimes in unexpected directions. The financial strength of the telecommunications sector has changed drastically. Regulation, under the leadership of a changed Federal Communications Commission (FCC), continues to react to these circumstances and play out the changes started by the Telecommunications Act of 1996. Meanwhile, telecommunications is no less important to the economy and broadband services have begun to change from a niche to a key economic necessity. This report looks at how the economic needs of Vermont drive the state's needs for advancements in telecommunications, at technological drivers in telecom, and at the financial, regulatory, and other trends that are shaping the industry.

A. Telecommunications and Economic Development

There is a new consensus that telecommunications infrastructure and services are key supports of the present and future economy in Vermont and the U.S. Information technology was a key contributor to increases in productivity since the mid-1990s. While computer advances were notable for a significant time before that point, it was not until the latter 1990s that U.S. Gross Domestic Product (GDP) began to grow at an annual rate of 4.1 percent per year, significantly higher than the rate of 2.4 percent per year in the first half of the decade. Widespread adoption of networking technology and the Internet in particular began in the mid-1990s. This makes computer communications, and not just information technology generally, an excellent candidate for the cause of this remarkable productivity growth. Decreases in the cost of computer equipment and equipment used for computer networking sustained this development.[1] The size of "the Internet Economy," online transactions and the services, infrastructure, capital and labor that support it, is staggering. According to a study by the University of Texas and Cisco Systems: "[T]he Internet economy will cross $800 billion [by 2006]. Today the Internet has enabled a new business model that Forester Research calls 'Dynamic Trade,' which is fundamentally altering the creation, delivery and pricing of products and services."[2] Yet the increases in productivity noted here impact the traditional economy as well as the "Internet Economy." Vermont fails to keep pace with advancements in telecommunications networking at its economic peril.

"Today the Internet has enabled a new business model…which is fundamentally altering the creation, delivery and pricing of products and services."

Vermont faces constrained job and income growth prospects through 2007.[3] Yet perhaps unlike periods in the past when increases in economic activity or growth in developed areas were the drivers for improved or expanded telecommunications, the present situation is somewhat different. The most important drivers of future requirements for Vermont's telecommunications infrastructure and services are not growth in economic activity or growth in developed areas, although these are likely to have some impact. Instead, the most important drivers of future requirements for Vermont's telecommunications infrastructure and services are competition, technological change and the economic and other opportunities that change affords. Four major sectors drive Vermont's economy: (i) manufacturing, (ii) hospitality and tourism, (iii) education and health care, and (iv) agriculture and natural resource-based production.[4] All of these sectors depend more and more on high-speed, reliable telecommunications service. Manufacturing in the United States is increasingly dependent on information technology and business-to-business networking that enhances productivity and enables American products to compete against cheap labor in a global marketplace. Broadband telecommunications fills a dual role for hospitality and tourism, providing a key marketing channel as well as an important amenity for travelers. Good wireless service is now considered vital by many travelers. Increasingly sophisticated communication over distance is ever more a mode of delivery for education and health care. Even agricultural and natural resource producers rely on modern telecommunications to access markets, suppliers, and information.

Other illustrations abound as to why an advanced telecommunications infrastructure is a key support for the Vermont economy. Vermont loses young workers at a rate more than three times the national average.[5] Young people, who are more likely to be tech-savvy, are unlikely to be attracted to a state that does not have an up-to-date set of broadband and wireless services. Conversely, Vermont has had a high level of in-migration, including high-skilled professionals.[6] High-quality broadband telecommunications services are essential to providing workers who have specialized skills the security that they can live and work in Vermont and still tap into economic activity in a national and global marketplace. Post September 11, 2001, real estate professionals indicate that there is increased activity from homebuyers who are relocating from major metropolitan areas to seek out Vermont's perceived safety and security.[7] Distance learning opportunities and access to on-line job search information is important to the vitality of Vermont's future workforce.[8] While all these examples of the importance of telecommunications to specific economic sectors or specific examples of economic development help to illustrate a point, the larger point is that telecommunications is important as a general support structure to the Vermont economy. Without advancing infrastructure and services, Vermont cannot reach its potential.

How important is it that Vermont's telecommunications networks continue to evolve and improve? Other states that have performed detailed studies of the economic promise of next-generation broadband services have drawn startling conclusions. Groups in both California and Michigan commissioned studies by Gartner Consulting to examine the economic impact of an accelerated broadband infrastructure. In the California study, Gartner modeled the economic impact of an increase in Gross State Product (GSP) over ten years resulting from an increase in broadband penetration from present levels to a level about halfway to the extent of telephone penetration. Gartner's model showed an increase in $376 billion in California's GSP and an additional 2 million jobs over 10 years.[9] If California's economy followed Vermont's, a proportional increase for Vermont would be $5.4 billion in GSP and 40,000 jobs (or roughly the current workforce of IBM in Vermont times six).[10] A similar Gartner study for the LinkMichigan initiative put the 10-year Michigan GSP increase from a state-wide broadband infrastructure at $440 billion along with a nearly half a million increase in jobs over the same period. The highest projected growth rate was in sectors offering high pay and requiring high skills: information, utilities, professional, scientific, and technical services, and finance and insurance.[11] These estimates were based in part on International Telecommunications Union (ITU) studies showing that "teledensity"—the density of communications connections per capita—is strongly correlated with a country's Gross Domestic Product. A key to obtaining the benefits that Gartner highlighted is increasing the level of adoption of broadband connections. This is due to the axiom that the value of a network increases exponentially with increases in the number of users.

Lest one think that Vermont should strive to reach a single benchmark level of service, such as ubiquitous broadband, it is important to note that the broadband goal is in the process of evolving. What "broadband" is today is likely not to be considered "broadband" tomorrow. Indeed, the title of the California study was "One Gigabit or Bust." While such speeds may seem extravagant, consider the following analogy:

> Only 20 years ago, the average business desktop computing device required a mere 9.6 kilobits per second (Kbps) of bandwidth. Today the average business desktop is networked using 100 megabits per second (Mbps)—an exponential increase of 10^5 the power. If we apply a similar increase to the U.S. Federal Communications Commission (FCC) definition of today's broadband at 200 Kbps, we'll require a speed of 20 gigabits within 20 years. Consequently, one gigabit broadband to every education institution, business and home by 2010 is a realistic goal.[12]

Meeting the future telecommunications needs of Vermont's economy will require a sustained effort.

B. Trends In Technology

For many decades, voice telephone service has been the core telecommunications service. Data communications is surpassing voice in this role, but while this is happening, the way voice is delivered to customers is changing. The old model of a communications channel linking two people over wires is bending to accommodate the maturation of packet and wireless technologies.

FAST PACKET SERVICES

For much of the history of the telecommunications industry, its services have been provisioned over circuits and circuit switching. Circuits are dedicated communications paths established between users, either on an on-demand or permanent basis and circuit switching establishes a dedicated path of communication (or a dedicated time slot within the shared path of communication) for the duration of a communications session. When one makes a phone call, the telephone network has traditionally established a circuit between the caller and the called party.

A little less than ten years ago, so-called "fast packet" services (distinguished from previous generations of slower packet data services, like the X.25 service) were just beginning to take hold in Vermont. Frame relay, still an important fast packet service, provided an important alternative to networks of dedicated high-speed point-to-point data circuits, such as T-1 circuits. (See Figure 1.1.) A customer with a location requiring connectivity to a number of other locations could obtain a single connection to the frame relay network instead of multiple connections to the multiple sites or "daisy chaining" sites together. In Vermont, frame relay also was the vehicle that introduced data connectivity options at points in between 56 kbps and 1.544 Mbps for those customers who had a greater need for speed than a 56K data line would provide, but could not afford a full T-1.

Packet-based services break streams of communication into piece parts (the "packets") and route the pieces of many individual communications through a network or networks of common channels, reassembling the parts at their destination. Packet-based services use communications bandwidth more efficiently

Types of Fast Packet Services

The diversity and capability of fast packet services have increased in recent years. Carriers use a variety of protocols to manage and deliver packets. These protocols are not necessarily mutually exclusive; in some cases a protocol of one type will transit a network operating under a protocol of another type, such as when IP packets are encapsulated in ATM packets to transit an ATM network. Here are a number of the major types of fast packet services (not all of which are widely deployed in Vermont).

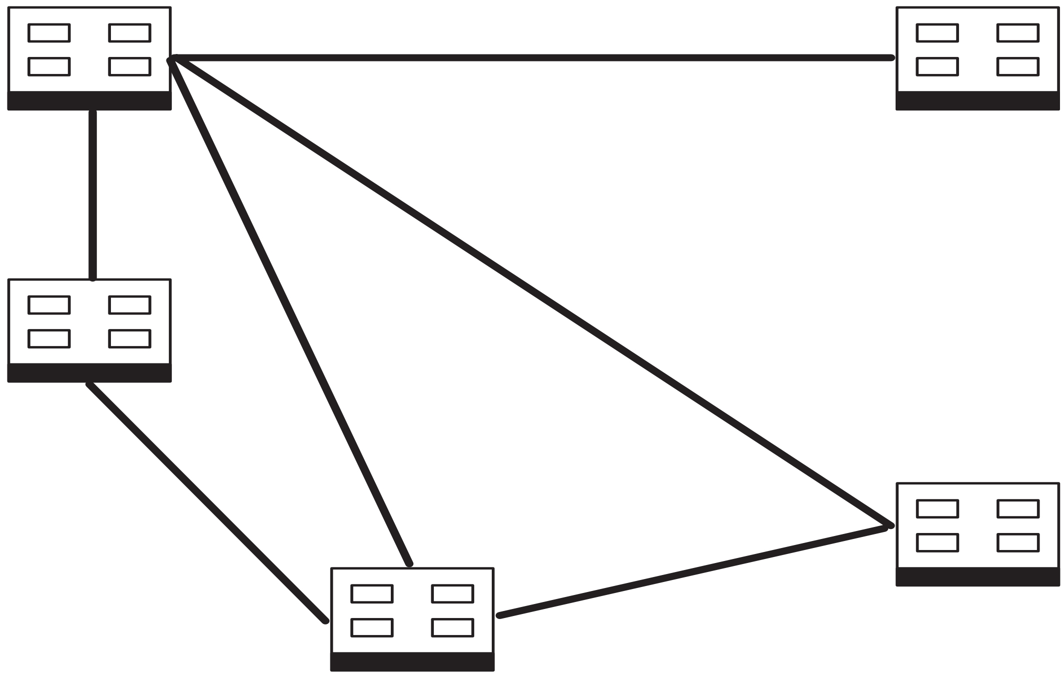
- **Frame Relay** is a relatively simple fast packet switching that originated in the telco networks. It can supplant networks of point-to-point dedicated circuits with "virtual circuits" provisioned over a shared wide area network.
- **Asynchronous Transfer Mode (ATM)**, a "cell relay" service, offers potentially greater data transmission rates and a greater ability to predictably manage different kinds of packet data streams, including ones with quality-of-service requirements, such as voice and video. (ATM is the basis of the Vermont Interactive Learning Network.) However, ATM offers this management capability at the price of high "overhead" of packets used not for transmission of the data payload, but management of the service.

A competing trend is the use of data transmission protocols that have become widespread first in computer networking.

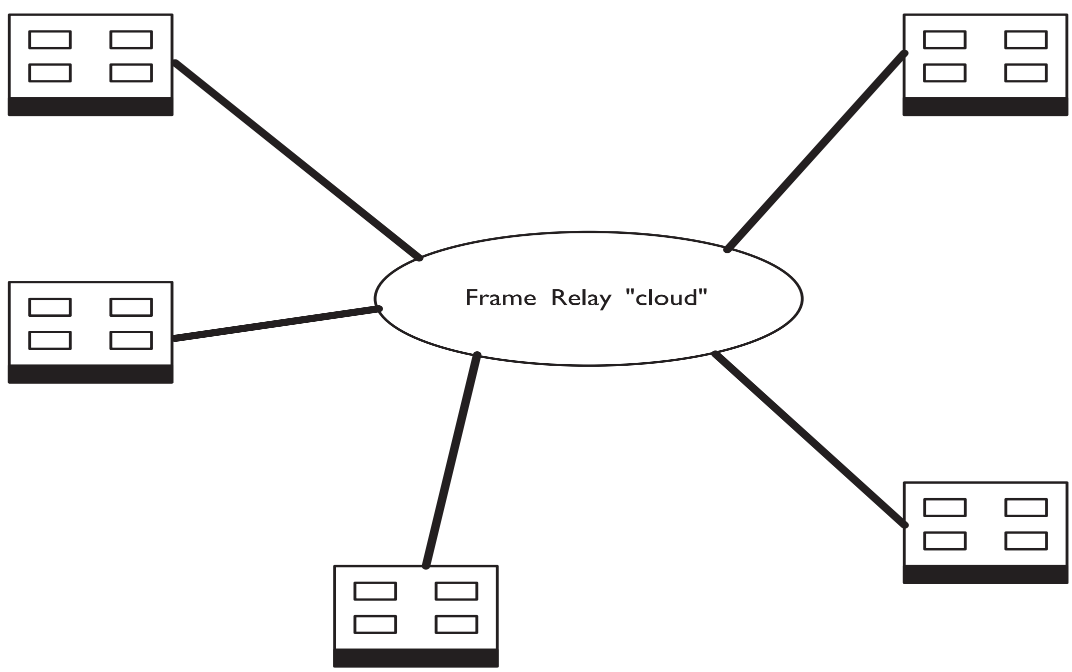
- **Internet Protocol (IP)** is a language of the Internet which is increasingly the basis for managed, "native" IP networks. Frequently it is a networking protocol used as a means for carrying communications through networks using other underlying protocols.
- **Ethernet** is the dominant protocol of the Local Area Network (LAN) that has invaded telecommunications networks in a big way. It is a highly mature line of networking protocols with a very large base of equipment manufacturers. While the availability of traffic prioritization is its weak point, it is seen as a relatively inexpensive way to deliver very high speeds (10 Megabit, 100 Megabit, Gigabit and higher) from the backbone to the desktop over one protocol.
- **Multi-Protocol Label Switching (MPLS)** works with other protocols like ATM, IP, and frame relay, adding "labels" that enhance the ability of packets to transit networks based on these protocols and maintain managed quality of service.
- **Resilient Packet Rings (RPR)** feature Ethernet's ability to efficiently transport very large amounts of data, with little overhead. However, the RPR protocol has been designed to operate over rings, and quickly re-direct traffic in case of a cut in the ring. It also has built-in support for prioritizing different kinds of traffic.

Figure 1.1:

Point-to-point networks vs. frame relay



When point-to-point connections are used to link many sites, the result may be a complex network.



Frame Relay, ATM, and similar services provide individual sites with a single link to a "cloud" through which connections are made to all other desired sites.

than circuit-based services by using those parts of a communications session where the parties are not "saying" anything to transmit packets from other communications. Packet-based services were once exclusively the province of data services. Data transmission has usually been much more tolerant of packet-based services' traditional drawbacks in the face of congestion, such as the possibility that packets would be delayed in transmission or not arrive in the order in which they were sent. Increasingly, packet-based services are sophisticated about how they manage and prioritize packets, or are able to provide large enough transmission capacities to forestall congestion. In short, packet-based services are becoming the dominant means of telecommunications and are in the process of supplanting circuit-based communications for even the transmission of voice and video communication.

Unlike voice service, which is an integrated network offering universal access through multiple carriers, fast packet services are more likely to be offered as unconnected networks by individual providers. (IP, the protocol of the Internet, is a notable exception.) In part this is due to the fact that there are different protocols (ATM, Ethernet, etc.) Even the same services offered by different providers do not necessarily make up an integrated network. For example, Vermont does not have a frame relay network, but multiple frame relay networks. Customers must choose a single provider. If that provider does not service all the customer's locations then alternate arrangements must be made, such as linking to the fast packet provider at some location through leased point-to-point dedicated circuits.

VOICE OVER PACKET NETWORKS

Voice is data, not voice and data. That is the essence of the application of packet technology to the provision of voice services. The transport of voice over packet-switched networks will become increasingly important over the next seven years, increasingly working its way into a larger and larger proportion of the voice system.

[W]here IP telephony is used either with separately provisioned bandwidth or with supporting quality-of-service technologies, it has proven to be competitive with circuit-switched technologies. –Computer Science and Telecommunications Board, The Internet's Coming of Age

In the traditional circuit-switched network, a series of switches create a set of dedicated pathways to transmit each call and then tear down that pathway at the end of the call. Packet networks are like the Star Trek transporter, breaking down communications into small pieces of information, routing them through the network flexibly and reassembling them at the communication's end point.[13] The transmission of voice over packet networks can take a variety of forms. In some cases the packets will travel over the public Internet and in other cases they will travel over private networks monitored closely for quality of service. Some specific applications of voice over packet networks include:

- Voice over the Internet. New service providers like Vonage (www.vonage.com) and Packet 8 (www.packet8.net) increasingly try to market their services as something more than the "making a call on the computer" model, offering a regular telephone number and adapters that allow customers to utilize a regular phone. One source places the number of U.S. households making Internet calls with standard phones at 100,000 in 2003, and estimates growth to 4 million households by 2007.[14]

The Difference Between Packet and Circuit Switching

Circuit switching is the traditional way of making sure that the voice of one person in a call is routed to the party on the other end of the call. Circuit switching sets up and ties up the entire capacity of a caller-to-caller circuit for the entire length of a call, even though voice communication is full of pauses. Turning the voice communication into packets of data and routing them over a shared packet-switched data network inherently makes more efficient use of the network, as the pauses in one communication's use of the network provide opportunities for another communication to use the same capacity. Depending on the network (or piece of the network), that other communication may be other voice traffic, or any other form of packetized data, allowing voice to share a single network with more traditional data traffic. Indeed, individual voice conversations do not require high data speeds. Early attempts to use packet networks for voice were hampered by voice's requirement that the packets arrive without delay and in the correct order so as to form an intelligible conversation—requirements that are not present to make an intelligible e-mail message, for example, because it is not real-time communication. However, there are now more sophisticated options for managing the traffic on packet networks that address these problems. There are also many data networks with enough spare capacity that voice traffic need never compete with other data.

- Private-network voice-over-IP. Packetized voice data can be carried over the same local or wide-area network that links an organization's computers, and indeed the computers and the phones can be networked together. Voice-over-IP allows an organization to manage (and pay for) one network instead of two and use excess capacity in a data network. IP voice systems offer flexibility in assignment and re-assignment of extensions and can be upgraded with software. Data from In-Stat/MDR indicates that applications like this are becoming commonplace in larger organizations—89% of large organizations currently have an IP VPN (Virtual Private Network), or plan to have one within two years. About half of all organizations using or planning to use IP VPNs plan to carry voice traffic on the VPN.[15]
- Carrier-class packetized voice. Local and long distance carriers are turning to packet data networks as a cheaper and more flexible way to create an ability to carry more calls over the same facilities, whether that is a local loop or a long-haul line. New generation digital mobile voice services are based on packet networks. These packetized voice services are invisible to consumers, appearing to be fully integrated into the traditional voice network. And indeed they are.

Cable companies are increasingly looking to packetized voice for their entry into local telephone service over their cable plant.

Many circuit switches are still likely to have a useful life that will extend through the next seven-year period, and perhaps beyond it. Certainly at least some service providers with existing investments in circuit switches will seek to extend the life of those investments. There will be fewer natural opportunities due to switch capacity exhaust to migrate early to packet switches in Vermont than there will be in some high-population states. Nevertheless, the overall trend toward packet switching suggests that the voice network of the future will be a data network at heart.

THE INCREASING IMPORTANCE OF SPECIAL ACCESS

While a wide variety of services from point-to-point dedicated lines to Digital Subscriber Lines (DSL) and fast packet services fall under the regulatory category of "special access," some older and more traditional services as well as the new entrants have grown in importance. Once a set of premium services with premium pricing for a small number of business and institutional users, services like T-1 lines are now more important to a wider variety of users. They provide the "backhaul" or the "middle mile" for new DSL and wireless Internet offerings. Smaller and smaller businesses and organizations are tapping T-1 offerings by combining multiple voice lines and high-speed data over a single line. T-1s provide a ubiquitous means of accessing other networks that may not be ubiquitous, such as fast packet switched services. In the past, these services were packaged as premium services. Now, with services like T-1 serving as a key element in so many new service offerings, this status may be changing.

VIRTUAL PRIVATE NETWORKS

Virtual Private Networks (VPNs) offer the ability to emulate a network of private leased data lines with a connection to a public shared network, such as the Internet or a single provider's data network. This greatly increases the possibilities for creating wide area networks due to reduced costs and the flexibility of using the widespread accessibility of the Internet and IP services. End users using a connection to the Internet can create VPNs. Creating quality-of-service levels is more difficult when VPNs are provided using the public Internet. Some telecommunications service providers offer managed VPN service: when points are connected via the same service provider's network, the service provider can realize a VPN with a managed quality of service. VPNs and especially VPN services offer the potential to enhance the readiness of Vermont locations to participate in distributed work.

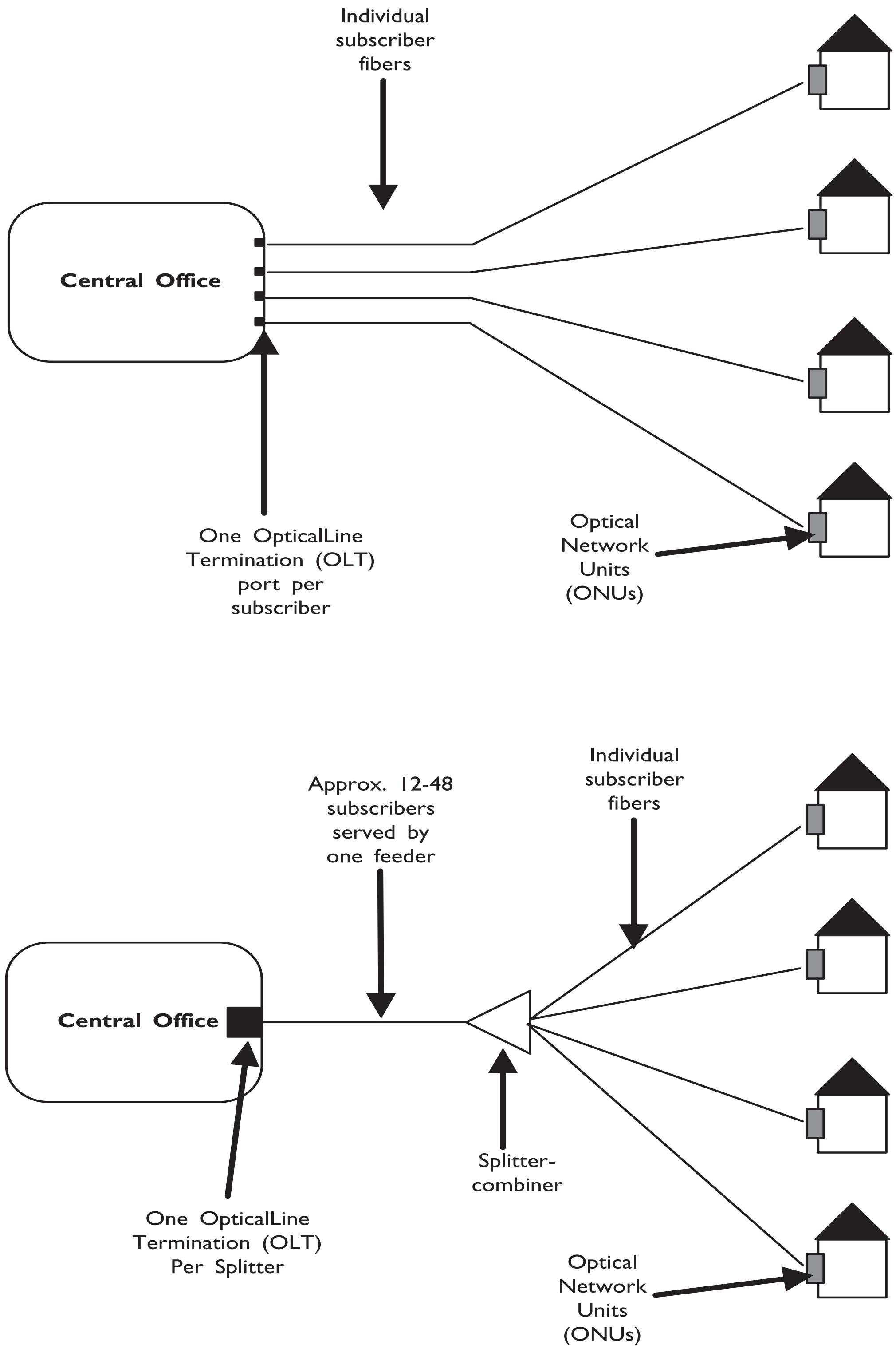
FIBER OPTIC COST TRENDS

For high capacity, low maintenance and an ability to support future increased bandwidth needs, it is difficult to beat fiber optics. Fiber is now the dominant medium on long- and medium-haul telecommunications routes. Cable companies have largely completed rebuilding their all-coaxial networks to a hybrid fiber-coaxial design that uses the glass fibers to connect headends with local neighborhoods. Telephone companies are using fiber in the "local loop," in the "feeder" portion that connects central office and equipment cabinets in the field. Fiber optic strands have taken over telecommunications backbones, increasingly displace copper in telephone feeder plant, and replace coaxial cable in connections between headends and nodes. The question

PONs vs. Home-Run Fiber Systems

Two major approaches to Fiber-to-the-User systems are the Passive Optical Network (PON) and home-run systems. (See Figure 1.2.) In some ways, a home run system is the model of simplicity—each subscriber has an individual fiber strand running from a central office location to their own premise. This is much like the telephone network in its simplest form, only with fiber strands replacing copper twisted pairs. Home run systems offer maximum flexibility for deployment of services, very high bandwidth in both upstream and downstream directions, and the greatest number of options for competition. A PON sends lightwaves down a single fiber strand shared by a group of customers to a splitter in the field. The splitter is small, relatively simple, unpowered and "passive." It simply divides the signal received from the central office and sends it down all the individual subscriber drops. The Optical Network Units (ONUs) at each subscriber location are programmed to only "read" the portion of the signal intended for the subscriber. All ONUs share the reverse-path bandwidth in a coordinated fashion, and reverse signals are combined at the splitter-combiner. The architecture of a PON is in some ways more like that of cable networks than conventional telephone networks. PONs are generally cheaper than home run systems, as costs for some of the fiber and electronics are spread among multiple users. While bandwidth is certainly more plentiful than under coaxial systems, users on a splitter do share the bandwidth available on the feeder fiber.

Figure 1.2:
Home run and PONs fiber systems



then becomes, when will fiber finally extend all the way to the home and business? For some business and institutional users located next to the fiber rings of certain service providers' networks, this is already the case, but when will it be commonplace? There is little doubt that all-fiber networks are technologically superior to the legacy coaxial and twisted-pair copper networks. The main barrier has been economic. The expensive labor involved in hanging or burying fiber and the cost of the sophisticated electronics result in higher up-front costs. The opportunities for offsetting those costs come in the form of lower maintenance and higher reliability, fiber's ability to transmit signals over longer distances than copper without regeneration, opportunities for more revenue over an infrastructure that can support voice, video, and very high-speed data and the high likelihood that the fiber network, (unlike copper and coax) will retain its essential usefulness for decades. Already there is an emerging consensus that fiber-to-the-user probably has roughly the same cost as copper in a significant "greenfield" development. Already developed areas present a greater challenge.

Cost estimates for fiber-to-the-user systems vary widely and depend on factors like the density of customers, pole attachment costs, burial options and whether the system is an upgrade of an existing system, a new build, or an overbuild. Key components in the cost equation are the costs of the electronics that sit at the user premises and the price trend for these components is downward. A glut in fiber production has also driven down the price of cables containing dozens of individual fiber strands.

While the cost of fiber-to-the-user systems represent a major investment, these seem the most likely systems to deliver data transfer rates exceeding today's broadband.

POWER LINE COMMUNICATIONS

Some in the telecommunications and electricity industries have been hailing the development of a so-called "third wire" for delivering broadband telecommunications to users, a wire that already runs to nearly every home and business in the country. Electric lines, which deliver electric power using low frequencies, can also carry broadband communications at high frequencies. The ability of power lines to provide broadband communications is well established. What is less certain is whether companies using this technology will be able to adapt the electric power grid, which is not specially designed for communications, to communications purposes economically, competitive with other service delivery platforms.

The typical model of broadband over power lines has the communications service "injected" on to medium-voltage power lines past the substation. Since high-speed communications does not readily pass through transformers, some sort of device is required to route communications to and from customers' premises and the medium voltage line. This may be a device that connects the medium and low voltage lines, bypassing the transformer. Connecting with the low voltage line means that communications are available anywhere an electric outlet is available by plugging in a device such as a power line to Ethernet converter. An alternative strategy connects the medium voltage line communications to a wireless transmitter, which provides the link to users in the immediately surrounding area. (See also subsection on unlicensed wireless communications, below.) Regardless of how the connection is made between the user and the medium voltage line, all users served by the medium voltage line share the total bandwidth capacity of the line, which tends to decrease with distance between the user and the injection point.

A major economic advantage of broadband over power lines is that there is little need to run new lines. In 2003, a survey of 100 utilities across the U.S. showed that one third were using, planning, or considering broadband over power line deployments.[16] However, customer densities still impact the economics of the technology. In particular, since transformers are barriers to overcome, it is more economical for the technology when more customers share a single transformer. In Vermont, many areas have a low density of customers per transformer. (In rural areas, the density can be as low as one customer per transformer.) Furthermore, the FCC is still examining how great is the potential for power line communications to "leak" and cause interference with various wireless transmissions. While FCC Chairman Michael Powell has signaled early support for the technology, certain interests such as Ham Radio operators are opposing it. In short, powerline communication is a promising technology that could play a part in providing either broadband coverage in unserved areas or additional choices to served areas, but the degree to which it will be commercially successful is still uncertain.

WIRELESS VOICE BYPASS

About two in five Americans now have a wireless phone and 61% of U.S. households had a wireless phone by mid-2001. Three to five percent of wireless customers use their wireless phone as their only phone. This number is growing, and the growth can be expected to accelerate. According to one forecast, by 2015 more than two thirds of North American households can be expected to use a wireless phone as their primary voice line.[17] According to a Yankee Group survey, about 15% of all wireless phone customers say they will jettison their wired phone in the next five years. According to a Management Network Group Inc. survey, about 19 million Americans would likely switch their landline numbers to a wireless phone number if the FCC allowed such switches, a move that could cost landline companies $14 billion a year.[18] The FCC in fact subsequently issued such an order in November 2003. While Vermont will almost certainly lag behind this trend, it will nevertheless be likely to have a significant impact here as well. An increased reliance by Americans on wireless phones as their primary voice connections will mean that users will expect a higher level of reliability and coverage from the service. It also suggests that landline telephone companies need to plan for a migration away from traditional voice service as the mainstay of their business.

INTERNET2 AND IPV6

The original Internet evolved and migrated from an "internetwork" connecting the networks of a relatively exclusive "club" of government agencies, educational institutions and selected companies to the wide-open "superhighway" we see today. Similar "clubs" of high-powered sites are still active today. Very high-speed research and development networks are prototyping applications including high-quality multimedia collaboration and virtual reality environments that may drive the further development of the Internet. The University of Vermont participates in the Internet2 network with over 200 other universities around the U.S.

Another evolution in the Internet is in its core routing and data packaging standard. IPv6 is the successor to IPv4, which is the standard that is currently widely deployed. While the transition from IPv4 to IPv6 has not progressed rapidly, IPv6 offers improvements that help remove barriers to even more widespread use of IP. First, IPv6 offers a vastly expanded address pool that will allow individuals and devices to be assigned static IP addresses with a freedom that is not possible today. This will facilitate applications that require lots of addresses that can be "seen" by the public network and do not change, such as IP wireless devices. IPv6 also provides improved options for security and for establishing service quality levels on IP networks. While IPv6 is still far from widely adopted, the movement to improve IP for a new generation of networks bodes well for the adoption of IP as the general-purpose telecommunications protocol.

Table 1.1:
Number of addresses in IPv4 and IPv6

Number of Addresses in IPv4	4,294,967,296
Population of Earth (2001)	6,170,000,000
Number of Addresses in IPv6	340,282,366,920,938,463,463,374,607,431,768,211,456

Source: http://ipv6.internet2.edu/

INSTANT MESSAGING

The stereotype of instant messaging (IM) is of a lightweight "chatting" tool firmly in the realm of teenagers. This stereotype belies the fact that "IM" and its close relatives (such as wireless text messaging and web chat pages) have grown up. IM occupies a space in between e-mail and phone calling; it is based in text but is real-time.

While IM retains its social element, it is also an increasingly serious tool. On September 11, when text messaging was in some cases the only way for people in the affected areas to communicate via overwhelmed wireless networks, it showed clearly how text messaging can be a very efficient communications medium in a high-volume situation. Businesses are increasingly using IM in their collaboration systems as a way to increase informal communication and collaboration among employees. IM has now been incorporated into groupware systems like Lotus Notes. Chat is also an increasingly important tool in customer service, providing customer service representatives a tool to communicate real-time with multiple customers. Two-way wireless text message systems can be as important (or more so) to a person who is hearing- or speech-impaired, as a cell phone is to someone without those impairments.

Although rooted in text, IM systems are now capable of carrying attachments, like e-mail, or presenting themselves in various non-text forms, such as pictures, video, or voice. IM services are offering the ability to initiate PC-to-phone calls.

Instant messaging is an important means of transmitting files in the current generation of peer-to-peer file sharing services, the heirs to Napster. The ability to send voice, files, or video over broadband connections presages the use of an evolved IM system for robust multimedia real-time communication. While voice or video communication over the public Internet are currently sometimes second-rate, the interface provided by IM programs and the large base of users mean that IM service providers are poised to capitalize on improvements in the level of service. This could ultimately provide another means of bypassing more traditional voice telephone communications. Furthermore, as the functional difference between IM servers and telecom company switches becomes fuzzier (each providing real-time routing of multimedia messages or communications between users), the basis for regulatory differences may become less distinct.

A feature that IM services offer that is not offered by most other real-time communications services is that of “presence.” IM systems provide users the ability to broadcast their level of availability to communicate to other users. In contrast, on the telephone network a user must make a call to find out whether or not a person is available. Presence provides the metaphorical ability for a person to open their door wide open, crack it, or shut it tight. In a world where people increasingly have the ability (if not always the desire) to be connected continuously, the idea of presence is powerful. The concept of actively managing one’s announced availability to communicate is powerful enough to spread to other communications media.

A serious problem with the world of IM and text messaging is the lack of widespread interconnection between messaging systems. In the U.S., users of dominant IM systems by AOL, Microsoft, and Yahoo cannot communicate with each other. Wireless text messaging systems may not be able to trade messages. This bears a resemblance to the early days of the telephone systems when multiple telephone systems serving the same city were not interconnected. And unlike the days of mutually incompatible Compuserve and AOL e-mail systems, there is no IM equivalent to the user base of Internet e-mail. Since networks are inherently more valuable the more users there are connected to them, there must be strong pressure for either eventual widespread interconnection and interoperability or the emergence of a single dominant IM provider. The current competition among IM providers has led to a proliferation of features and low (in fact free) usage prices. Interconnection and the development of interoperability standards is the alternative outcome to domination of IM by a single provider in addressing the incompatibility issues that the multiple providers raise.

TRENDS IN WIRELESS TECHNOLOGY

UNLICENSED WIRELESS DATA SERVICES

While operation in most of the radio spectrum requires an FCC license, in a limited number of spectrum ranges, the FCC permits unlicensed use of radio frequencies for a wide range of uses. Examples of these bands are 900 MHz, 2.4 GHz, and 5 GHz. Many people are familiar with digital cordless phones that operate in the 900 MHz and 2.4 GHz ranges. These are just two of the devices operating in these bands.

Service providers using free, unlicensed spectrum have been first to market with high-speed wireless data services in many areas (including Vermont). This is despite the billions of dollars spent on wireless spectrum licenses in the 1990s, much of it for high-speed data services. Unlicensed spectrum has a number of disadvantages. It can be especially subject to interference, since multiple uncoordinated users can attempt to use the same frequency in the same area. (In practice, this interference is less likely to happen in low-density areas and commercial users of the same unlicensed band have an incentive to work around their mutual problem.) The FCC regulates the manufacturers of devices for these bands, prescribing transmission strategies to limit the effects of interference, including limiting the power of transmitters and prescribing certain modulation techniques. Low power limits the range of these services. Nevertheless, unlicensed services have proven to have a number of economic advantages. Devices for operation in these bands have often been developed for the mass market originally. Wi-Fi wireless networking is an excellent example. It was originally deployed primarily as a way of creating wireless Local Area Networks (LANs). In some areas service providers or neighborhood co-ops (or just "generous" or security-lax network operators) discovered that the "LAN" could cover a neighborhood, a small downtown or a village depending on the antenna placement. Relatively low-cost equipment (due to the mass-market customer base and scale of production), a relatively large pool of innovating service providers (due to the lack of license restriction), and a relatively large base of users having or able to get compatible equipment (due to the 802.11b standard and other standards) has meant that service providers have been able to tinker, stretch, and expand the range of these systems. An increasing number of vendors are now making fixed wireless products for Wireless Internet Service Providers (WISPs) using unlicensed spectrum. Companies like Intel and Nokia have formed a consortium to extend the success of Wi-Fi by creating an industry standard for wireless wide area networks called 802.16 or WiMax. This standard could reduce the cost of equipment for mobile or fixed wireless Internet access that has an operating range of miles. The technology is expected to be broadly available in 2006.[19] The FCC is actively investigating granting more spectrum for wireless broadband and it seems not a question of whether unlicensed wireless applications will grow, but how much.

LICENCED WIRELESS DATA SERVICES

Service providers with licensed frequencies are also rolling out new wireless data services. This includes service providers using cellular or PCS frequencies. Third-generation or 3G wireless services represent a shift from a voice-oriented personal wireless services system to a data-oriented mobile packet data network, on which voice is one application. This will change the way that wireless services are used in a way similar to the way that DSL is changing the way that ordinary copper telephone lines are used. High-speed Internet access, transmission of remote mobile video or photography, and mobile remote connection to office LANs all become possible. Mobile packet data services such as cellular digital packet data (CDPD) have been available in the past but represent niche services. Widespread adoption of wireless packet data services will be a byproduct of the transition to delivering wireless voice services via a 3G packet network. In the U.S., a major barrier to the deployment of 3G services is the lack of allocated spectrum, unlike in Europe where spectrum has already been allocated. In the U.S., the military occupies the spectrum that has been allocated for global 3G services. A contentious debate has been raging at the federal level about whether and how to make available that spectrum or other spectrum. Certain wireless carriers in the U.S. have deployed "3G" services using existing spectrum. In Vermont, this includes Sprint PCS and Verizon Wireless. The announced data rates for these "3G" services are up to 144 kbps. Forthcoming services are expected to provide faster data transfer rates. Verizon Wireless has announced a nation-wide rollout of an even faster wireless data service with typical download speeds of 300-500 kbps, although the initial deployment is limited to a handful of major metropolitan areas. A potential barrier to additional deployment is the cost of licenses for new spectrum if and when it becomes available. 3G services are also likely to require still more wireless antenna sites with each covering a smaller area. These sites may not typically require new tower installations of the size of previous wireless service deployments.

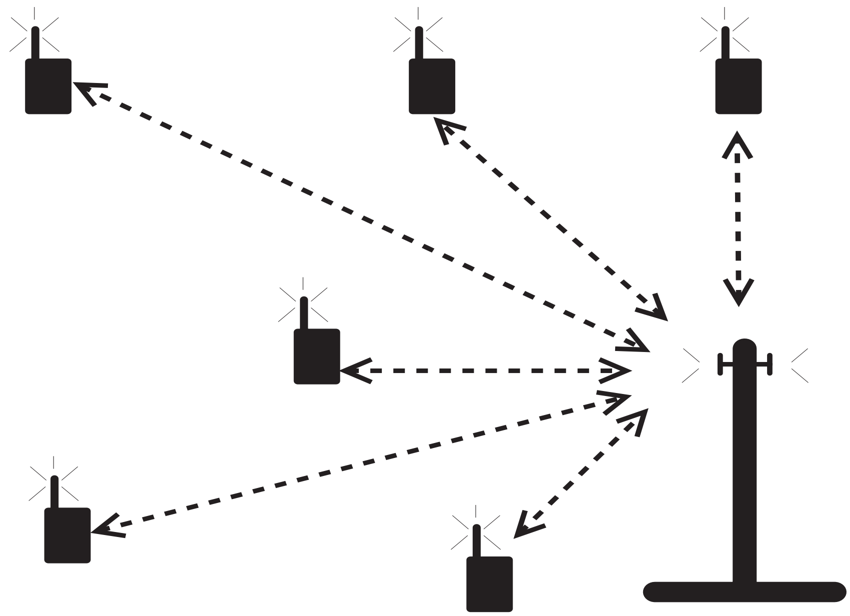
Licensed spectrum in the lower 700 MHz frequency range is another possibility for bringing high-speed Internet access to Vermont. This range is in the portion of the spectrum used by UHF TV signals on channels 52-59 and is being freed up as part of the migration to digital TV broadcasting. Under new FCC rules, this spectrum may be used for fixed, mobile, or broadcast services. Licenses for this spectrum have already been auctioned, although until the TV users have migrated, new lower 700 MHz providers must operate so as to avoid interference with the existing TV licensees. In Vermont, both Qualcomm and Vermont Telephone (VTel) won auctions for license areas covering all of Vermont. Since Vermont is not a major market, the economic viability of 700 MHz Internet access is likely to depend heavily on the extent to which manufacturers can produce volumes of equipment for the national market of service providers in the band. Vermont has fewer existing TV users that need to vacate the 700 MHz band, making it a promising location for early deployment once equipment is available.

ALTERNATIVE DEPLOYMENT STRATEGIES FOR WIRELESS SYSTEMS

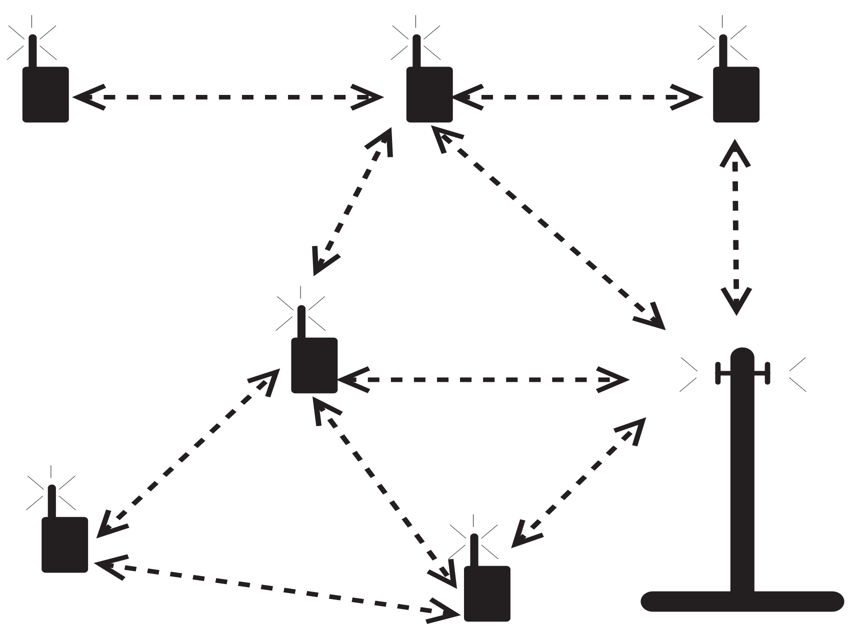
Strategies for deploying wireless services continue to evolve away from the "tower on a hilltop" model, although towers will continue to have some role especially in the more sparsely populated areas. Alternatives that require more transmitters and receivers (but smaller ones) can be expected to grow. This is especially true for services operating in higher frequencies (which naturally weaken faster with distance and are more easily blocked by obstacles), or operating with lower-powered user equipment.

In *mesh routing* each user's wireless device acts not only as a send-and-receive station for communication with a base station, but as a router that is capable of passing along communication between another end user's device and a base station or still another end user's device. (See Figure 1.3.) In many ways this mesh of communications paths is like the way the Internet operates and it is a natural for wireless packet-data services. Its key advantage is the ability to overcome distance and line-of-sight requirements between a base station and distant users because communication can hop from site to site. Furthermore, a greater

Figure 1.3:
Conventional wireless routing vs. mesh routing



In a conventional point-to-multipoint wireless network, all users must communicate directly with the base station.



Mesh routing provides multiple paths back to a base station, even for those users that may not have line-of-sight.

number of users increases the robustness of the network, providing a greater number of communication paths.

The size of available base stations continues to shrink. Installations might formerly have had high-power antennas perched atop high towers or other structures with large outbuildings containing electronics. Now some of these may be micro cells with cabinet-sized base stations, 4-6 foot antennas, and more flexible siting. Looking toward the future, other installations may be pico cells that may have antennas not much bigger than that on a cell phone. Smaller wireless equipment offers greater flexibility in the deployment of service; unfortunately they are most attractive in the areas of highest traffic or in indoor locations like malls.

Alternative deployments to the tower continue to grow in frequency. In Vermont, silos have become a surprisingly popular location for deploying antennas. One possible means of covering a roadway is to connect a string of small antennas to a base station with fiber optic or coaxial cable strung along utility poles. This method has been used more often in providing service to large indoor environments like stadiums and convention centers. The experience gained by the industry in this regard may translate into greater interest in using this deployment tool. Other alternative strategies for deploying service, especially in very large rural areas, include base stations and antennas mounted to aircraft, hot air balloons, or blimps. While worth watching, these deployment strategies do not yet have a proven track record and should not be depended upon to deliver service to Vermont anytime soon. Unfortunately, if a rural area does not have an available existing tall structure, a tower or monopole still may be the most cost-effective proven way of providing service to dispersed users.

Satellite phones are sometimes thought of as an alternative to terrestrial wireless services. They are unlikely to replace terrestrial wireless services in Vermont over the period of this plan for several reasons. Satellite phone communication is more easily blocked by obstructions such as buildings due to the need to communicate with a distant overhead satellite. Satellite phone equipment is somewhat bulkier and therefore less attractive to users. Satellite launches are expensive, capital-intensive, and riskier than terrestrial construction. Because of these disadvantages combined with satellite's key advantages of (i) widespread coverage even in remote areas and (ii) the ability to provide a back-up to terrestrial phone service, satellite phone service is most likely to be marketed as a niche service with a premium price, discouraging widespread adoption. Because Vermont is part of a larger market of wireless customers who travel between areas, the demand for terrestrial wireless service and network development in Vermont depends not only on the demand of local users but that of out-of-state users.

WIRELESS TELEMETRY

Requirements that wireless service providers make available more detailed information about caller location is part of the FCC's "Phase II" requirements for wireless E 9-1-1. This will accelerate the development of wireless telemetry, in particular the remote collection and analysis of data on the movement and location of people or objects, such as vehicles. While this raises serious privacy concerns, it also raises the possibility of a large number of new applications. Transportation applications, such as enhanced traffic management and better coordination of multi-modal trips (such as walking/bus or car/train) are one possibility. Customized selling or advertising based on a combination of the individual's personal preferences and location is another opportunity (or threat, depending on one's point of view).

SATELLITE DATA

The satellite data services market has expanded since the last edition of the *Vermont Telecommunications Plan* and indications are that this platform for delivering data services in Vermont will continue to develop and mature. Two-way service for the residential or small office user has now become commonplace. Satellite service providers, for a variety of prices, offer a variety of tiers of service from consumer-grade Internet access at speeds comparable to cable modems, to wide area networking services at speeds comparable to T-1 levels of service. Satellite provides a key advantage: the ability to reach locations out of reach of services like DSL or cable. For this reason, it is likely to be an important means of filling in the high-speed access map in the immediate future. The ability to reach where there is little or no competition has also tended to allow the service to obtain a price premium compared to cable or DSL services. Satellite data services are not an exact substitute for terrestrial data services. Today, these services are delivered via satellites in high geostationary orbits, which appear from earth not to move in the sky and allow dishes to be pointed at them. This high orbit means that an approximately half-second round-trip delay is introduced into communications. (You can observe this on the television news in the interviews via satellite of reporters in remote locations.) For many applications, such as web surfing or e-mail, this produces no noticeable effects. It may be long enough, however, to complicate such applications as remote access to a LAN. Real-time voice and video communications operating over the data service would also be noticeably degraded.

TRENDS IN CABLE NETWORKS

CABLE CONVERGENCE

While cable operators in Vermont have not yet been active either here or in other parts of the country in introducing telephone services, major cable operators elsewhere have been promoting telephone-over-cable systems. There are in excess of 2.5 million subscribers already around the country and cable operators could take a significant market share of local telephone lines over the coming years. Earlier efforts at cable telephony used systems that mimicked the circuit-switching system of traditional telephone networks. New offerings are expected to be voice over cable system operators' private IP networks. The same systems that are used to offer cable modem service are being leveraged and extended to offer voice service. These services offer the same kinds of cost advantages as other VoIP services and prices for some services are striking—such as a $34.95 Cablevision package that includes unlimited local and long distance service.[20]

Table 1.2:
Cable phone subscribers

Comcast	1,367
Cox	839
Insight	42
Charter	26
Cablevision	12
Total	2,286

In thousands, as of June 30, 2003

Source: Company reports and UBS estimates

DOCSIS

Cable Labs' DOCSIS (Data Over Cable Service Interface Specification) provides the basis for the development of standardized equipment that enables the offering of new or improved services over the cable network. DOCSIS 1.0 defined standardized ways of communicating high-speed Internet traffic over the channels of the cable network. DOCSIS 1.1 offered the ability to define various tiers of service or levels of quality that could be offered to different kinds of customers. DOCSIS 2.0 specification should enable increased "upstream" throughput, making possible symmetric data services.

ISP ACCESS TO CABLE SYSTEMS

The emergence of cable modem service as the most common form of broadband Internet access has sparked debate about the future of the Internet access marketplace. For dial-up Internet service, a multitude of Internet Service Providers (ISPs) have used the common infrastructure of the telephone network to offer service. Cable systems are considerably less open. Generally speaking, cable systems are only open to the cable company's affiliated Internet service, or the affiliate and a small number of other ISPs who have negotiated private deals with the cable operator. Small cable operators may have unaffiliated ISPs on their system. In Vermont, Duncan Cable's carriage of SoVerNet is an example. These arrangements are not typically open to all comers. A call that went up in the late 1990s for "open access" on cable systems was blunted by a subsequent decision by the FCC that cable modem services were neither "cable services" and therefore subject to local franchising authorities, nor "telecommunications services" subject to common carrier regulation. Instead, it found that they were "information services," the same federal regulatory classification under which dial-up ISPs have fallen. In contrast, in the 2001 Vermont Public Service Board (PSB) decision granting Adelphia Cable new franchises, the PSB tentatively concluded that cable modem service was not a cable service under Vermont law but was a telecommunications service. The Federal 9th Circuit Court of Appeals in the so-called "Brand X" decision recently overturned the FCC's decision. The Ninth Circuit, upholding its finding in an earlier case, found cable modem service to have both a "telecommunications service" component and an "information service" component. Unless overturned on appeal, the decision will be returned to the FCC for further deliberation.

Although classification of cable modem as a "telecommunications service," at least in part, provides regulators with additional tools for ensuring that cable operators do not discriminate among content riding on their services, it may do little to provide unaffiliated ISPs access to cable systems. The FCC has indicated that even if cable modem service is a "telecommunications service," it may consider it an interstate telecommunications service, pre-empting state regulation. It has also indicated it could forbear from much of the regulation it would have the power to impose on an interstate telecommunications service. In brief, there is a significant likelihood that cable systems will be closed to most ISPs for the foreseeable future.

VIDEO ON DEMAND/DIGITAL VIDEO RECORDERS

Video on demand (VOD) and the Digital Video Recorder (DVR) represent new modes of programming delivery on cable or satellite systems offering consumers the ability to watch programming when they want to watch it. Programming may be offered on either a subscription model, a pay-as-you-go model, or both. VOD rollouts are happening now on cable systems across the country, including in Vermont. VOD essentially operates like a high-quality streaming video system, but is limited to the cable system. It offers consumers more control over what they are watching, but how much control operators and content providers will grant them and what the business model requires are still open questions. At issue are such things as the amount of programming that will be offered on a VOD basis, the presence of advertising and the ability (or lack thereof) to skip it. The viability (and importance) of VOD will also be affected by the success of DVRs (e.g. TiVo) and Internet streaming video. The former seems poised to mount serious competition to VOD services. There are at least 4 million households with DVRs, and Forrester Research predicts that by 2004, 27 percent of U.S. homes will have DVRs and one-third will have VOD.[21] Cable companies and satellite companies alike are integrating DVRs into their digital set-top boxes. DVRs especially are poised to change the way advertisers use the television medium by allowing users the freedom to skip ads.

OTHER TELECOMMUNICATIONS TECHNOLOGY TRENDS

SATELLITE RADIO

In late 2001 and early 2002 two new services, Sirius and XM, launched, each delivering a hundred or more channels of music and talk radio via digital satellite transmission. These services, while offering a diversity of radio programming previously unavailable in any one area, are also national in scope. This is an advantage for long-distance travelers who do not want interrupted coverage or to hunt for new stations. It also means that the programming does not have a local element. Commercial-free and subscription-based (at $10-13/mo.), these services are currently a premium offering. They are likely to remain viable at least as a niche service, but it is possible that they could become more popular. (The inclusion of satellite radio systems in some new cars by major automakers suggests this could be the case.) To the extent that these systems begin to reduce the listenership of local terrestrial radio and the business case for local radio stations, Vermont may see an erosion of that mode of communication, both for everyday communication and for such things as emergency broadcasts.

DIGITAL BROADCAST TV

Digital broadcast TV, not to be confused with digital cable TV, will offer viewers in one over-the-air broadcast signal either one high-definition television (HDTV) programming stream, multiple standard-resolution simulcasts, or a standard resolution broadcast and "datacasting," the transmission of high-speed data in the broadcast signal. "Datacasting" offers the possibility of providing high-speed data efficiently to anyone who can receive a TV signal. Unfortunately it is one-way, and without an effective return path, it is questionable how many users will obtain the necessary hardware to receive datacasts. A key challenge with the conversion to broadcast digital TV will be the need to re-construct the antennas of the TV stations in Vermont, many of which are located on mountaintop sites including Mt. Mansfield, Burke Mountain, Rutland, and Mt. Ascutney. Currently the federal deadline overseen by the FCC for a full transition to digital broadcast TV is by the end of 2006 or when the penetration rate for digital television receivers reaches 85 percent. Until then, broadcasters are occupying two sets of frequency spectrums for simultaneous analog and digital broadcast. Once the threshold for all digital broadcast is met, broadcasters will be obligated to return their excess spectrum (including 700 MHz spectrum), which will then be available for other purposes. The transition to digital broadcasting suffers from something of a chicken-and-egg problem that many observers anticipate will delay the final transition and return of spectrum. Broadcasters are reluctant to produce digital broadcast programming without an installed base of digital receivers. Consumers are reluctant to buy TVs that include digital receivers without plentiful digital programming. Further complicating the situation is the fact that the majority of consumers receive programming via cable and satellite. These outlets have been reluctant to commit to carrying digital broadcast programming which, unlike digital cable, has the potential to use more bandwidth per channel, not less. In an effort to circumvent the impasse, the FCC has required that half the TVs with screens of 36 inches or more sold in this country have digital tuners by 2007.

C. Other Industry Trends and Developments

FEDERAL PREEMPTION

A number of unfolding developments may erode Vermont's ability to directly influence the development of its telecommunications infrastructure. Over the past several years, a number of decisions have been made at the federal level to limit state authority over new or emerging services. These new and emerging services are becoming increasingly important parts of the telecommunications network. The Telecommunications Act of 1996 pre-empted state authority for personal wireless services (including cellular and PCS service) over rates and health standards and limited authority over siting. Perhaps more importantly, the FCC in 2002 issued decisions declaring that DSL service and cable modem services are interstate "information services," which could have the effect of removing their underlying networks from state regulation. Even though the Ninth Circuit Court of Appeals recently overturned the FCC's decision on cable modem services by ruling that cable modem service had both telecommunications and information service components, that decision still leaves the FCC with considerable leeway to remove cable modem facilities from state oversight.

At the same time as services like DSL and cable Internet access have been declared interstate services, the FCC has frozen the interstate/intrastate separations ratio for a period of five years. This freeze expires in July 2006. This means that interstate revenue can continue to grow while intrastate sources of revenue, from second lines and local minutes of use, threaten to stagnate.

What are "separations" and why do they matter?

States and the FCC have traditionally split the regulation of telecommunications services. Some services, such as local exchange service (the piece between the customer and their local switch), are considered to have both interstate (federal) and intrastate components. "Separations" is the process for dividing up the costs and revenue for these services. State regulators are responsible for establishing rates that will cover the intrastate portion of the costs and the FCC is responsible for establishing rates to cover the interstate portion of the costs. Services are classified as "interstate" or "intrastate," and the revenue earned on each goes to the interstate and intrastate requirements, respectively.

As a practical matter, some of these decisions do not radically change the likely outcome of regulation in Vermont. It seems unlikely, for example, that the PSB would regulate the price of wireless service at this point even if it had the authority to do so. Two key and related areas where it could make a difference are on issues of open access and the availability of key elements of a broadband infrastructure. In the cable modem case, the FCC essentially decided that the transport element and the services riding on it were one and the same. While the FCC's recent decision on DSL was very similar, it may not necessarily mean that states do not still maintain the ability to regulate the facilities used to provide DSL, keeping them open for other services or service providers. It does at least create sufficient confusion about that issue to threaten the concept of open network architecture.

On one issue, there is the possibility that federal preemption could impact regulation in Vermont greatly. In 2001, the FCC issued a Notice of Proposed Rulemaking (NPRM) on the subject of developing a unified intercarrier compensation regime.[22] Intercarrier compensation is the system of payments that telecommunications companies make to each other to originate, terminate, or transport each other's calls. This compensation varies by a number of factors, including whether the call made is local or long distance, interstate or intrastate, wireline or wireless, or circuit-switched. Technology and competition together are reducing the viability of this system by introducing ambiguities and inconsistencies into the system and providing opportunities and incentives for companies to seek out a more favorable rate of intercarrier compensation. The NPRM proposed a simplified "bill and keep" system for all forms of intercarrier compensation, one where companies would generally recover their costs from their own customers and not each other. Significantly, the NPRM contemplates the possibility that this could extend not only to interstate charges, but to intrastate charges regulated by state public utility commissions, including the PSB. Since the NPRM there has been little formal action in the docket by the FCC, but a wide range of companies have engaged in private negotiations in an effort to come up with a consensus proposal. As of mid-2004, these efforts had not yet borne fruit and the results were uncertain.

FINANCING CONSTRAINTS ON INFRASTRUCTURE INVESTMENT

Telecommunications investment has endured a period of unfriendly capital markets, making investment that much more challenging in Vermont's market. Although nearly all segments of the telecommunications industry have been affected by the tightening of capital investment, one indicator of the challenge is the level of spending by the newer entrants to the telecom marketplace; capital spending by competitive local exchange carriers (CLECs) was $10.7 billion in 2002, down from $21.7 billion in 2000.[23] There are several potential or actual bases on which capital funding for telecom (including cable) investment in Vermont can rest.

- National commercial capital markets. These are most significant for companies with a footprint that extends beyond Vermont. The financial markets are likely to be wary of many telecom investments for the near to mid term at least, due to the collapse of so many firms around the country in this market. The companies most obviously affected by this situation are upstart competitors to incumbent local exchange telephone companies and expanding wireless carriers. While this situation is serious, and affects national and regional telecommunications companies operating in Vermont (such as Verizon and Adelphia), it may perhaps have changed things less for Vermont than some areas of the country because some significant local companies have never had meaningful access to these markets.
- Vendor financing. During the heyday of the telecom bubble, many telecom manufacturers self-financed the purchase of their equipment and facilities by service providers. Many of these loans have defaulted, leaving manufacturers in a weakened position.
- Venture capital. The small number of appropriately sized venture capital funds focused on Vermont is a problem that the Department of Economic Development has recognized and worked to change. Venture capital funding has not been significant so far for telecom in Vermont. Venture capital funding also imposes severe constraints about payback periods and rates of return that are not compatible with investment in long-lived, long-payback investments in telecom.
- Local bank financing. This is an important source of financing for small, locally based companies providing competitive telephone, cable, or high-speed Internet service. It has its limits, as it is a conservative funding source with little special understanding of telecom investment.
- Revenue reinvestment. Use of a revenue stream to finance investment has been important for several categories of companies. Some companies, such as cable companies, have a certain degree of freedom (due to few competitors and no effective rate regulation) to raise prices, providing more money for major reconstruction or expansions of systems. A number of relatively non-diversified independent telephone companies have very low debt-to-equity ratios, indicating that revenue has sufficed to finance the company's investments to a significant extent. Some locally-owned Internet service providers or cable companies expanding into high-speed data services have used the revenue from their existing lines of business or a slow "pay as you go" model to incrementally finance their new venture by necessity, due to a relative lack of alternative financing. Revenue reinvestment may be less likely to happen as a matter of course when the company is heavily diversified, has a geographically broad footprint, and does not have a mechanism that strongly ties earnings to investment.
- Federal loan and grant programs. A number of programs, especially through USDA's Rural Utilities Service (RUS), have traditionally existed to fund

infrastructure improvements in rural areas. These programs have not been widely used in Vermont. The most recently passed Farm Bill contained some new loan and grant programs for broadband service deployment. Other proposals for broadband investment programs have come up from time to time in Congress in recent years. A key obstacle may be that information about these programs is difficult to obtain and regulations about the use of funds may make it unclear what projects in Vermont would qualify for funding.

- Local or state-level public investment. There have been few examples in Vermont of direct public investment. The City of Burlington's Burlington Telecom is a notable exception and has deployed fiber optics to serve city and school telecom needs. It is now starting to make this infrastructure available to other enterprises in the city, including on a wholesale basis to other service providers. The Department of Public Safety (DPS) has recently made a major investment in upgrading a statewide voice and data microwave system, but this system is only for use by public-sector agencies. In some other jurisdictions, direct public investment has been more prominent in developing systems ranging from long-haul fiber optic routes to new cable TV systems to fiber-to-the-home integrated voice, video, and high-speed data delivery systems. They are frequently controversial and have been so in Vermont. In some cases, jurisdictions are attracted to public financing tools such as bonding because the long term of public bonds is similar to the expected useful life of certain (but not all) telecom infrastructure elements, like fiber optic strands.
- Local or state-level loans or tax incentives. This has not been a source of funding thus far in Vermont. Arguably, a number of state tax structures currently create a disincentive to investment. This includes the sales-and-use tax, which is imposed on telecommunications equipment and facilities purchases. Also, the taxation of cable outside plant property at fair market value instead of net book, as telecom facilities are, can potentially lead to large property tax increases when cable plant is rebuilt to enable new services.
- Traditional utility-based financing. This is not a special "source" of funding *per se*. The combination of a captive base of customers and regulatory approval to recover through rates a stable rate of return over long periods on prudently made investments creates special conditions for private investment. A few companies—namely the independent incumbent (non-Verizon) telephone companies—fall into this category, and they have had different investment patterns than Verizon or the competitors in Verizon's service territory. Nearly all of these companies have invested heavily in recent years in modernizing their networks and rolling out DSL service widely. Unlike competitive upstarts, they still have near-monopoly control over their base of telephone customers. Their monopoly service includes a basic, essential service, telephone. Unlike Verizon, they are rate-of-return regulated, meaning that that their earnings are directly related to their levels of investment (assuming that their rates are under possibility of regular review). Under Verizon's price-cap regulation plan, investment is more discretionary, assuming the company can otherwise meet the expectations of the alternative regulation plan. The differing form of regulation is not the sole factor contributing to the differences between the companies. A number of inde-

pendents have taken advantage of low-cost RUS loans. Several are locally owned and less diversified with comparatively fewer alternative investments close at hand. Also, most independents have benefited from a federal pooling mechanism that allows them to pool a portion of their costs and revenue. This pool links the companies' compensation much more strongly to the amount they invest in services like DSL than to the amount of revenue they collect from them (which is returned to the pool), greatly reducing the riskiness of the investment.

- Market pre-qualification. This too is not a source of funding *per se*, but a means of improving the case for financing from some source. A number of companies operating in Vermont with limited access to financing have used this tool by only building in a locale or along a route when they have pre-sold service to a number of customers or have in place an "anchor tenant" for their service.

In summary, the availability and terms of financing for telecom ventures is a key element in the continued development of Vermont's telecommunications networks. Some industry players have not seen dramatic changes in the sources and types of financing that they use. For others, the burst of the "telecom bubble" has left them more constrained.

TELEPHONE NUMBERS

Telephone numbers seem mundane, but their assignment and availability are key issues that have a significant impact on Vermonters. There continue to be significant developments in this area, as Vermont continues to monitor the rate of depletion of numbers in the 802 area code, sees consumers have more opportunities to keep their telephone numbers, and witnesses pressures to weaken the tie between telephone numbers and local geography.

A preeminent numbering issue in Vermont is the preservation of Vermont as a state with a single area code, 802, which is highly identified with the state. According to the April 2004 forecast issued by the North American Numbering Plan Administrator (NANPA), the 802 area code NPA (numbering plan area) is forecast to exhaust, or run out of new unused and useable blocks of numbers in the first quarter of 2012. This new deadline has been pushed back almost five years since the 2002 forecast. These forecasts have seen significant volatility, in some cases moving back, and in other cases accelerating. Once the reserve of number blocks in the 802 NPA dips below a certain reserve, an additional area code for Vermont is almost inevitable and once implemented, irreversible. Therefore, it is important to postpone this point as long as possible.

In 2002, the PSB implemented thousands block pooling in Vermont, a significant step to extend the life of the 802 area code. Shortages of numbers in NPAs are caused not so much by a shortage of individual telephone numbers but a shortage of continuous blocks of numbers. In years past, telephone numbers were assigned to telephone companies in blocks of 10,000 numbers. If an incumbent company needed a new block of numbers to accommodate growth in an exchange or a new competitor needed numbers to begin providing service to an exchange, 10,000 numbers were assigned to the company even if its immediate or even foreseeable need was much less. Now numbers may be assigned in blocks of only 1,000 numbers, which greatly increases the efficiency with which numbers may be assigned.

To understand how the implementation of thousands block pooling is extending the life of the 802 area code, it is helpful to examine a few key statistics. First, Vermont has 141 telephone exchanges. Each telephone company serving customers in an exchange requires at least one block of numbers—more if it has a greater number of customers. There are 800 possible NXX codes in the area code and 54 are unavailable for assignment to customers, having been reserved for special purposes. Hypothetically then, if every exchange in Vermont had multiple competitors serving it and each competitor served every exchange in the state, there could only be five telephone companies at most, including the incumbent, in a competitive market. Since there are more than six CLECs operating in Vermont, and in some exchanges telephone companies are already using multiple NXXs, it is fortunate that not all competitors have requested NXXs in all telephone exchanges. Nevertheless, a number

Figure 1.4:
NXX code utilization in area code 802

June 2003

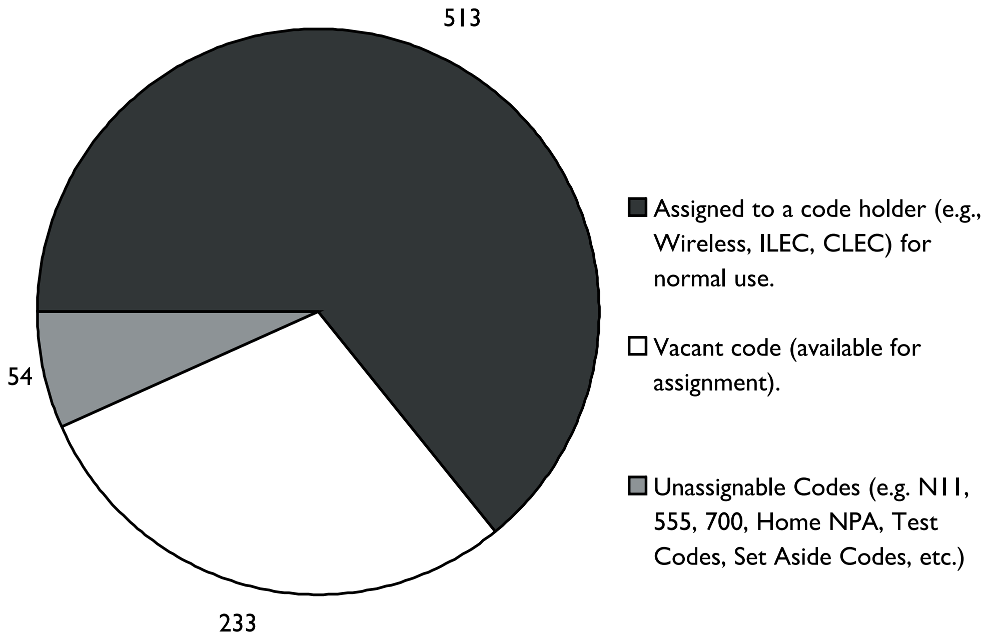
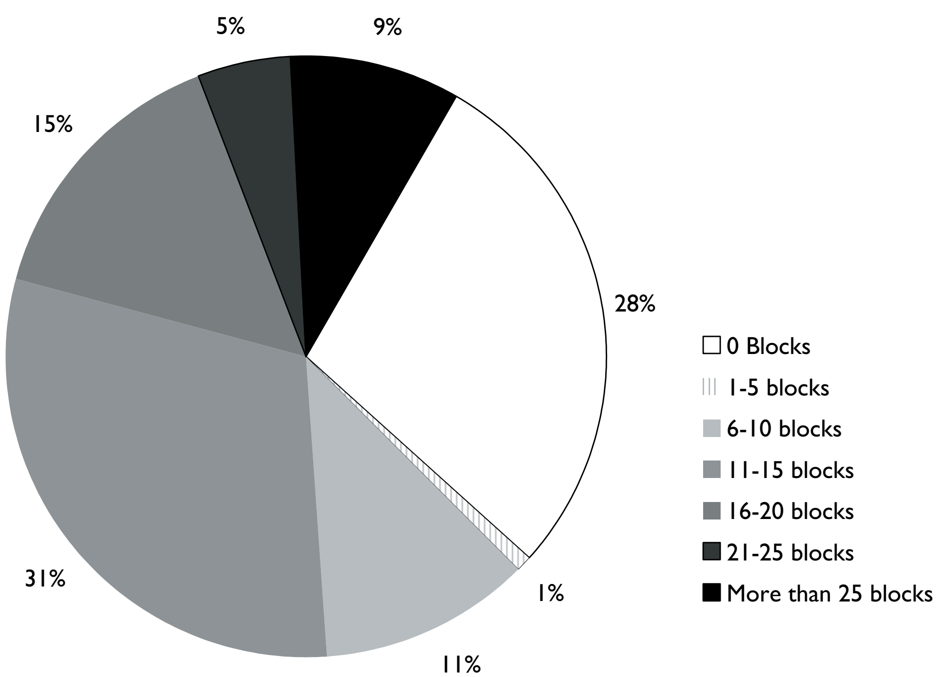


Figure 1.5:
Percentage of exchanges with donated blocks available

June 2004



of CLECs and to a lesser extent wireless companies, have requested blocks in a significant portion of the 101 exchanges served by Verizon. As a result, only about one third of the available NXX codes in the 802 area code remain unassigned. (See Figure 1.4.) Prior to thousands block pooling, requests by only two or three new CLECs or wireless carriers for NXXs in all or most Verizon exchanges would have faced the state with an area code split (dividing the state into two parts, and assigning all customers in one part a new area code) or overlay (assigning new phone numbers only out of a new area code statewide, which would require all calls be dialed with an area code). This was a distinct possibility. Now, requests for a block from most carriers will be filled not by a whole NXX, but by only 1/10th of an NXX, a thousands block. As Figure 1.5 shows, a majority of exchanges in Vermont had more than ten available blocks as of June 2004 that carriers have "donated" out of little-used portions of their assigned NXXs. Several of the larger exchanges most likely to see additional requests for thousands blocks due to growth or new carriers (Burlington, Rutland, and Montpelier) had much larger reserves of donated blocks (66 blocks, 72 blocks, and 55 blocks, respectively). The 28% of exchanges with no donated blocks belong to independent telephone companies that are not yet required to pool numbers. (Although it is possible that may change in the future). In short, thousands block pooling has created a buffer, a reserve of blocks that will delay the need to open up new NXXs in many exchanges.

While much of the risk of a jeopardy situation for the 802 NPA has been removed, there are still scenarios under which the NPA could be rapidly depleted. Since not all CLECs are required to pool, a request by 2 or 3 such carriers for NXXs in most of Verizon's exchanges could remove most of the remaining NXXs. A CLEC that was not required to pool would also not be able to port the numbers of new customers from their prior carriers, which would be a competitive disadvantage to most CLECs.

Local Number Portability (LNP), a federal requirement that gives consumers the ability to take their number with them when they change carriers, is now a reality for most consumers, although not for customers of independent telephone companies and a handful of CLECs. Wireless carriers have recently been required to port numbers between each other, increasing competitive choices for wireless telephone customers. Now that both wireless and wireline industries have been required to port numbers, the FCC has ordered porting of numbers between wireless and wireline services. This

Anatomy of a Telephone Number

The telephone industry uses certain combinations of letters to refer generically to the various parts of a ten-digit telephone number.

- The *NPA*, or Numbering Plan Area, refers to the portion of the number occupied by the area code.
- The *NXX* or "central office code" refers to the first three digits of a seven-digit telephone number, or the first three digits after an area code. NXXs are usually associated with a particular telephone exchange. The letter "N" means a digit between 2 and 9, inclusive. The letter "X" stands for any digit between 0 and 9, inclusive.
- The last four digits, *XXXX*, can also be any digit between 0 and 9, inclusive.

An NXX is also known as a "ten thousands block." An NXX plus the first digit of the "XXXX" series of digits is known as a "thousands block."

802-828-2811

NPA NXX XXXX

will greatly increase the ability of consumers to substitute wireless telephone service for their traditional access lines. In addition, only carriers who have implemented LNP are required to participate in thousands block pooling, so the growth in LNP is contributing to the life of the 802 area code.

Traditionally, there has been a strong correlation at many levels between telephone numbers and geography. This correlation has been used in telephone ratemaking. Area codes have been assigned to specific states or regions within states; and NXX codes to particular local exchanges. Customers only received telephone numbers associated with their particular geographic location (unless they paid significant charges for foreign exchange service), and usage charges for making telephone calls were often based on the distance between the called and calling parties. A number of trends have been weakening the correlation between location and telephone numbers.

- The cost of long-haul transport of traffic has decreased dramatically, especially with the national glut in long-distance fiber optic capacity. This has encouraged long distance companies to reduce or eliminate differences in price between long haul and short haul traffic. The increased use of Internet or IP based systems for transporting voice has only strengthened the trend.
- Mobile telephone service has further weakened the connection between a telephone number's apparent location and the user's actual location. While wireless telephone numbers are assigned to particular telephone exchanges, they typically give their users very large regional or even national "local" calling areas. Wireless companies routinely assign subscribers telephone numbers associated not with their exchange of residence, but with a nearby exchange. The FCC has determined that wireline companies could port such numbers from wireless companies, even though the customer might have a telephone number different than their physical exchange. Furthermore, since the location of mobile phones changes and since decreased roaming charges are now offered on many wireless calling plans, there are few barriers to a user having a telephone number in one locality but spending significant time on the phone at some distance away from that locality.
- Competition in the local market has brought with it de-emphasis on switching traffic locally and a greater use of transport. CLECs in Vermont are likely to haul all their calls to a single point in the state for switching, or even to an out-of-state switch. Verizon and competitors may also need to bring local traffic they exchange with each other to a single point of connection. With the increased use of longer-haul transport for even local calls, there are more situations where the costs for a local telephone company to transport a call over distance are similar to the costs to transport it locally.

Indeed one of the most significant ways in which local and long distance calls differ is in their regulatory treatment, especially in the differences in intercarrier compensation paid to complete calls. Long distance calls are subject to access charges while local calls are subject to the lower reciprocal compensation (which may involve no exchange of money between carriers). While Verizon's access charge rates have declined significantly, independent telephone companies still depend heavily on them. Regulatory differences between local and long distance calls are no longer as strongly reinforced by transport costs. Network design creates tensions with the regulatory framework as carriers and users attempt to introduce new ways of using telephone numbers that blur the distinction between local and long distance. One way this has manifested itself in Vermont is the use of remote or "virtual" numbers. Essentially, customers obtain a telephone number in an exchange that is distant from their physical location at rates below the expensive rates that would have been charged for foreign exchange service in the past. The most notable use of these numbers has been to provide ISPs with dial-up Internet access numbers around the state. This practice has been the subject of two investigations. One was an arbitration of an interconnection dispute between Verizon and the CLEX Global NAPs in which the PSB ruled against the way in which Global NAPs was deploying "virtual NXXs." Docket 6209 is the PSB's long-running investigation into the use of these numbers generally. Even as the PSB threatens to crack down on the use of virtual telephone numbers in Vermont, Vonage and other Internet-based telephony providers have begun to offer subscribers their choice of local or remote area codes around the country when they sign up for service, additional remote numbers for only $5/month, and the ability to take numbers when moving to a new location (a feature that mobile phones already offer).

Number portability and the new services that offer new number choices create new opportunities for consumers. These put pressure on the traditional regulation of number usage, and while the pressure on the 802 area code has decreased significantly, this may well be only a temporary reprieve.

ACCESS LINE GROWTH

An indicator of the change moving through the telecommunications industry is the change in access line growth by incumbent Local Exchange Carriers (LECs), which over the history of the industry dependably has risen. From 2000 to 2002, the incumbent LEC share of access lines declined by about 9 million (4.7%). This change is probably due to several factors including wireless phone substitution, a slowing in the demand for second lines due to slowing demand for dial-up Internet access, and competition. The total demand for lines has not gone down, and the total number of lines served by incumbents is not going down, just changing in nature. More lines are being provided at wholesale, not retail, and more line equivalents are being provided over special access circuits like T-1s. Taking these factors into account, line and line equivalents served by incumbent LECs increased by about six million between 2000 and 2001.[24]

BROADBAND ADOPTION TRENDS

While there is considerable debate in some circles about the depth of demand for broadband services, broadband nationally is in fact continuing to grow at very respectable rates. While broadband households are still a fraction of total households, this fraction continues to grow despite the current economic climate. At year end 2002, almost a quarter of online households nationwide used either DSL or cable modems. In New England, 33% of online households were broadband households.[25] By 2004, another survey estimated that 39% of U.S. adult

Internet users have a broadband connection at home.[26] Broadband continues to be adopted at rates that are consistent with past trends in the adoption of consumer electronic devices and services. A typical pattern of technology adoption follows an "S" curve. (See Figure 1.6.) Broadband has been in the lower, shallow part of the curve, since the early phase of adoption. In fact, the rate of adoption for broadband by households has been similar to that of their adoption of Internet access itself. It is easy to forget that Internet access penetration took approximately eight years to exceed 20% of U.S. households. It was not until 2001 that the percentage of households with Internet service exceeded 50%.[27]

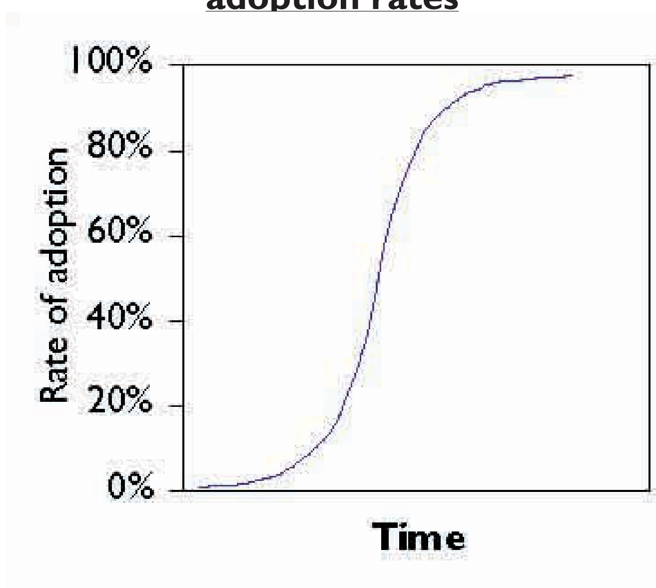
Table 1.3:
Years for past consumer technologies to exceed 20% penetration rate of U.S. households

	Years
Radio	5
Television	6
Pay Cable	14
VCRs	8
Internet Access	8

Source: Vanston, Lawrence K., "Residential Broadband Forecasts." Technology Futures, 2002.

These numbers give no reason for complacency. A reasonable forecast of broadband penetration could put broadband penetration levels in only five years near the point where Internet penetration levels are now or even higher—at 60%-80% of U.S. households. This could be true even if not all households have access to broadband. In ten years it is very possible that three quarters or more of U.S. households will have broadband service.[28] What is currently a relatively respectable level of broadband penetration in Vermont is unlikely to stay that way. Vermont subscribership must continue to grow strongly in order to keep up with probable growth in the use of this technology in other states and countries.

Figure 1.6:
The "S-curve" for technology adoption rates



Cable modem service adoption leads DSL nationally. A 2003 investigation by the FCC concluded that approximately 71% of U.S. households had access to cable modem service, with a take rate of about 11%, while DSL was probably available to less than half of Regional Bell Operating Company customers.[29] DSL subscription rose significantly in 2003, however. In March 2003, an estimated 67% of home broadband users nationally connected via cable modem, compared to 28% by DSL, 4% by wireless or satellite and 1% by T-1 or Fiber-to-the-Home services.[30] By February 2004, 54% of home broadband users connected with cable modems, 42% with DSL and 3% with wireless or satellite. Cable modem subscribership did not decline; instead, DSL subscribership grew more rapidly.[31]

THE UNBUNDLING DEBATE

The Telecommunications Act of 1996 set the stage for the FCC to require that the Regional Bell Operating Companies (RBOCs), such as Verizon, provide access by competitors to their services and network. Services are available for resale at a wholesale discount, and pieces of their networks (such as the local loop, local switching, interoffice transport, and dark fiber) are available at discounted unbundled network element (UNE) rates. Competitors have been allowed to recombine all of the UNEs needed to provide the "platform" for a complete service (UNE-P). As the Act passes its eighth anniversary, the future of unbundling is clouded with uncertainty. The FCC has made several attempts to implement unbundling rules, only to have them repeatedly struck down in court. The most recent of these undertakings came in mid-2003 in during the FCC's "third triennial review."[32] In March 2004, the D.C. Circuit Court of Appeals overturned in part and upheld in part the FCC's rules. Significantly, the court upheld rules that did not require unbundling of next-generation networks but struck down rules that allowed states discretion in making determinations about competitors' access to UNEs. In August 2004, the FCC issued interim rules continuing access by CLECs to RBOC switching, enterprise market loops, and dedicated transport elements on terms contained in interconnection agreements in effect on June 15, 2004, but only for six months. After six, months, if new permanent rules are not in place, the interim rules allow RBOCs to increase prices by at least 15% on for elements serving existing customers, and allow greater increases for elements to serve new customers. The interim rules expire at the end of 12 months. FCC Chairman Michael Powell has stated that he intends to complete new permanent rules by the end of the first six-month period and has also stated a lack of enthusiasm for preserving UNE-P.[33] Verizon and other RBOCs have gone to court to block the FCC from implementing its interim rules pending a final rulemaking. At this point it is difficult to predict exactly what unbundling requirements for Verizon and the other RBOCs will look like, even in the relatively near future, but it is likely that competitors will enjoy reduced access and higher prices on at least some UNEs.

D. Conclusions

Trends point to future telecommunications networks that are packet-based, have both wired and mobile elements, flexibly carry a wide variety of applications, and are on a path in increasingly high speeds. Change is a common theme among telecommunications trends.

- The telecommunications industry is seeing the progression of a number of disruptive technologies, including voice over packet networks, increased use of mobile services, and the maturation of multimedia, Internet-based alternatives to traditional voice.
- Broadband communications are in the process of maturing into a new basic, multi-purpose communications platform and the bar for what can be considered broadband speed may very well rise in the foreseeable future.
- Regulation is in a period of change, driven both by changes in technology and law and policy. Regulatory bodies will face pressure to change and adapt.

Vermont may not rest on its laurels if it is to continue to have necessary levels of telecommunications services. A key challenge for Vermont is the question of where financing for future needed investments in Vermont's telecommunications network will come from. Competitive and wireless providers lack the access to capital sources that were common a few years ago. Adelphia is emerging from bankruptcy and is significantly constrained. Verizon is no longer operating under traditional regulation and is a company with a multitude of investment pressures outside the state. At the same time, continued sustained progress must be made to upgrade and extend Vermont's telecommunications infrastructure if Vermont is to maintain its economic vitality. While broadband and wireless service and infrastructure should continue to advance, there is uncertainty about how rapidly and whether it will reach all corners of the state. Making sure that every Vermonter continues to have access to affordable high-quality telephone and data telecommunications services from one or more service providers in a new, increasingly competitive environment will be an essential task for the state.

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